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Six common mite species (Acari) in Norwegian coniferous forest soils: Relations to vegetation types and soil characteristics

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With 7 figures

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Contents

1. Introduction

Previous studies have shown that artificial changes of soil *p*H have markedly influenced the mite fauna of forest soils (e.g. HÅGVAR & ABRAHAMSEN 1980, HÅGVAR & AMUNDSEN 1981, HÅGVAR & KJØNDAL 1981). For several species, the abundance seemed to be related to soil acidity. In the studies, soil *p*H was manipulated by liming [$CaCO_3$ or $Ca(OH)_2$] or by application of diluted sulphuric acid. However, relationships between abundance and soil chemical parameters should also be tested under natural field conditions. With this background, the abundance of six mite species has been related to chemical properties of various coniferous forest soils. The soils range from acid and poor soils to rich mull with rather high *p*H. The selected species belong to the most common mites within their respective groups in Norwegian coniferous forest soils. Three of them belong to Oribatei (*Tectocepheus velatus* [MICHAEL], *Nothrus silvestris* NICOLET and *Brachychochthonius zelawaiensis* [SELLNICK], two belong to Astigmata (*Schwiebea cf. nova* VITZTHUM and *S. cf. cavernicola* [OUDEMANS]), and one to Mesostigmata (*Parazercon sarekensis* WILLMANN). The first four species tended to increase their abundance in acidified soil and to become more rare in limed soil. *Parazercon sarekensis* could be reduced by both acidification and liming. In one experiment, the dominance (among Astigmata) of *S. cf. cavernicola* was increased by liming.

In the present study, the abundance of these species in different soils has been related to a number of soil chemical factors. The occurrence is also related to soil and humus types, plant communities and soil fertility. Finally, the vertical distribution of each species is presented. Parallel studies have been performed for the Collembola fauna in the same sites (HÅGVAR 1982, HÅGVAR 1983, HÅGVAR & ABRAHAMSEN in manus).

2. Habitats, material and methods

HÅGVAR (1982) gave information about the vegetation and main soil characteristics of the sampling sites. The soil profiles were described in more detail by HÅGVAR (1983). Chemical parameters

from the upper 0—3 and 3—6 cm were presented by HÅGVAR & ABRAHAMSEN (1984). Seven different vegetation types in each of two study areas (A and B) in SE Norway were studied. These have been ranged below according to increasing soil fertility: (1) Cladonio-Pinetum *(Cl-Pn)*; (2) Barbilophozio-Pinetum *(Ba-Pn)*; (3) Vaccinio-Pinetum *(Va-Pn)*; (4) Eu-Piceetum Myrtilletosum *(Eu-Pc My)*; (5) Eu-Piceetum Dryopteris *(Eu-Pc Dr)*; (6) *Melico-Piceetum typical (Me-Pc ty)*; (7) Melico-Piceetum Athyrium (*Me-Pc At)*.

Two habitats of the richest vegetation type were studied in area A. These were named A_1 and A_2.

Some more information about the habitats will be given in the subsections of the next chapter, where the abundance of each species is related to different vegetational and soil properties.

Sampling was performed in spring (May/June) and autumn (August/September) in each habitat. The sampling and extraction procedures were described by HÅGVAR (1982). One sampling in a given habitat consisted of twenty soil cores of 10 cm^2. Chemical analyses were carried out on the pooled twenty soil cores for each habitat from the autumn sampling. The chemical analyses were performed according to OGNER *et al.* (1975, 1977). Soil *p*H was measured in a soil: water suspension of 1 : 2.5, and the cation exchange capacity was based on ammonium acetate (*p*H 7) extraction. The concentrations of cations represent exchangeable amounts, while Nitrogen is given as total N.

Relationships between mite abundance and soil chemical properties were tested on a volume basis. The number of animals was per m^2 in each depth level, and the concentrations of chemical elements were given per dm^3. Due to the limited number of plant communities, the correlation between abundance data and single soil chemical parameters was based on ranking of the parameters, using the Spearman's rank correlation coefficient.

A multiple regression analysis was also applied to test possible combined effects of two or more chemical parameters. However, as for Collembola (HÅGVAR & ABRAHAMSEN 1984), these results were not consistent. Within a given species, quite different combinations appeared in different samplings, and the second important factor in the regression analysis was often not correlated to the number of animals.

3. Results

3.1. Relations to vegetation types and soil fertility

The countings were limited to the upper 6 cm. Some specimens of *Schwiebea* sp. could also be found below this depth, but the other species only very rarely penetrated deeper. In all species, the season with the highest abundance varied from habitat to habitat, so there was no systematic difference in numbers between spring and autumn.

Fig. 1 shows the relative distribution of each species on the different plant communities. All species could be found in all vegetation types, with the exception that *Parazercon sarekensis* was not recorded in *Me-Pc At*. However, the abundance could vary greatly between

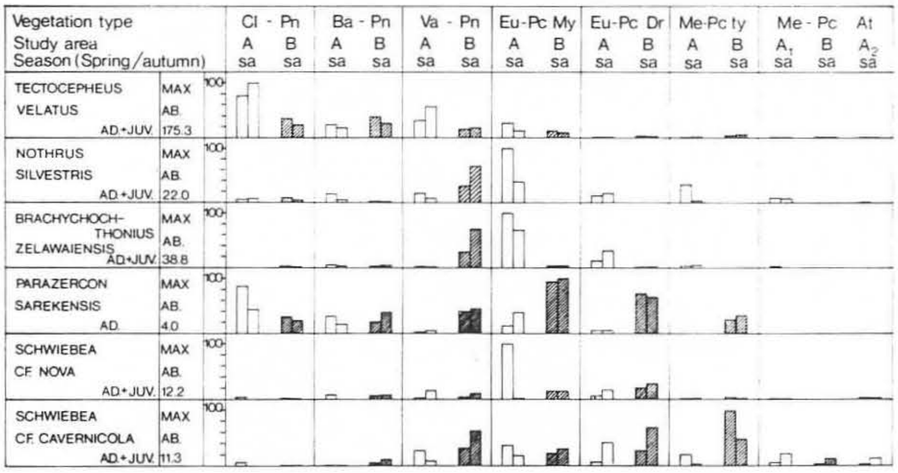

Fig. 1. Relative abundance of each mite species in different plant communities. Soil fertility increases from left to right. Columns from area B are hatched. Maximum abundance values (in thousands per m^2) are given to the left, and have been set at 100% for each species.

the different vegetation types. *T. velatus* is clearly most abundant in the four poorest vegetation types, while *N. silvestris* and *B. zelawaiensis* achieved highest numbers in *Va-Pn* or *Eu-Pc My*. *P. sarekensis* was well represented in all the six vegetation types where it was found. The two *Schwiebea* species occurred mainly in the three medium rich vegetation types, but *S. cf. cavernicola* also extended its main range into richer soils (Fig. 1).

3.2. Relations to soil and humus types

The five first vegetation types in Fig. 1 usually have an iron podzol soil with raw humus, while brown earth with mull humus is characteristic for the two richest categories (*Me-Pc ty* and *Me-Pc At*). Exceptions were a peat soil in *Ba-Pn* (area A), a brown earth in *Eu-Pc Dr* (area A), and a granular raw humus in *Me-Pc ty* (area B).

No species follows completely the pattern of soil and humus types (*cf.* Fig. 1), so these factors alone cannot explain their distribution. However, all the species in question are most common in raw humus, with low abundance in all mull soils.

3.3. Relations to soil chemical properties

In each species, the relationships between abundance and soil chemical properties were tested separately in the two study areas, seasons and depth levels (0—3 and 3—6 cm). The maximum number of significant relationships per species was therefore eight.

Table 1 shows in how many of the eight samplings each species was significantly correlated to the different soil chemical properties. A few inconsistent results, where both positive and negative relationships to a given parameter were recorded in the same species, have been deleted from the table.

T. velatus gave the most consistent picture. This species which occurs mainly in the poorer podzol soils with raw humus (Fig. 1), showed negative relationships to several parameters which increase with increasing soil fertility (*p*H, base saturation, Ca, Mg, Mn, *cf.* Hågvar & Abrahamsen in manus). These parameters turned out to be negatively correlated to *T. velatus* in as many as 5—8 samplings (Table 1).

As the reactions to artificial acidification and liming are known for these six species (see Introduction) the abundance values have been plotted against soil *p*H in Figs. 2—4. The four "acidophilic" species *T. velatus, N. silvestris, B. zelawaiensis* and *S. cf. nova* were always scarce or absent in soils with *p*H above five. However, in the more acidic soils with *p*H values around four or below, even these species might be rare or absent. None of the species showed good linear relationships to soil *p*H. In *T. velatus*, a curved relationship may exist.

3.4. Vertical distribution

The vertical distribution (0—3 and 3—6 cm depth) of each species at the various samplings appears from Figs. 5—7. Only samplings with more than 20 animals of the relevant species were used (corresponding to 1000 m^{-2}). The spring sampling from *Cl-Pn* in area A was excluded because of few soil cores from the 3—6 cm layer.

All species showed large variations in depth distribution, both between habitats and seasons. No relationship could be found between vertical distribution and habitat, season, study area, soil type, humus type or soil profile.

T. velatus was the species which lived highest up in the soil profile. On the mean, 85% of the animals inhabited the 0—3 cm layer. Both the two other Oribatids, the large *N. silvestris* and the small *B. zelawaiensis*, were about equally distributed on both layers. The juveniles of *T. velatus* and *N. silvestris* showed a vertical distribution which was similar to that of the adults.

In certain samples, *P. sarekensis* was found abundantly in the 3—6 cm layer, but on the mean, 65% of the population was confined to the upper 3 cm. The vertical distribution of the two Astigmata species varied greatly, but the total material showed an approximately equal distribution between the layers for *S. cf. nova* and a somewhat stronger preference for the uppermost layer in *S. cf. cavernicola* (51% and 60% in the 0—3 cm layer, respectively).

Table 1. Significant relationships (positive or negative) between the abundance of six Acari species and soil chemical parameters

	N	*p*H	Base	Ca	Mg	Mn	Na	K	IGN	In both study areas:
Tectocepheus velatus, ad. + juv.		⊖⊖⊖— —	⊖⊖⊖⊖ ——	⊖⊖—— ———	⊖⊖⊖— —	⊖——— ——				—*p*H, —Base —Ca, —Mg, —Mn
Nothrus silvestris ad. + juv.		—	⊖—	——	—					
Brachychochthonius zelawaiensis, ad. + juv.		—	—	—		—				
Schwiebea cf. nova, ad. + juv.	—						—		—	
Schwiebea cf. cavernicola, ad. + juv.			+		+		—	⊕	—	
Parazercon sarekensis, ad.	⊖	⊖	⊖—	——	———	⊖⊖—	—			—Mg

Note: Each + or — indicates a relationship found in one sampling covering 7—8 different habitats (Spearman's test). Ringeld symbols: $p \leqq 0.01$, otherwise $p \leqq 0.05$. Base = base saturation %, IGN = loss on ignition. Further explanation in text.

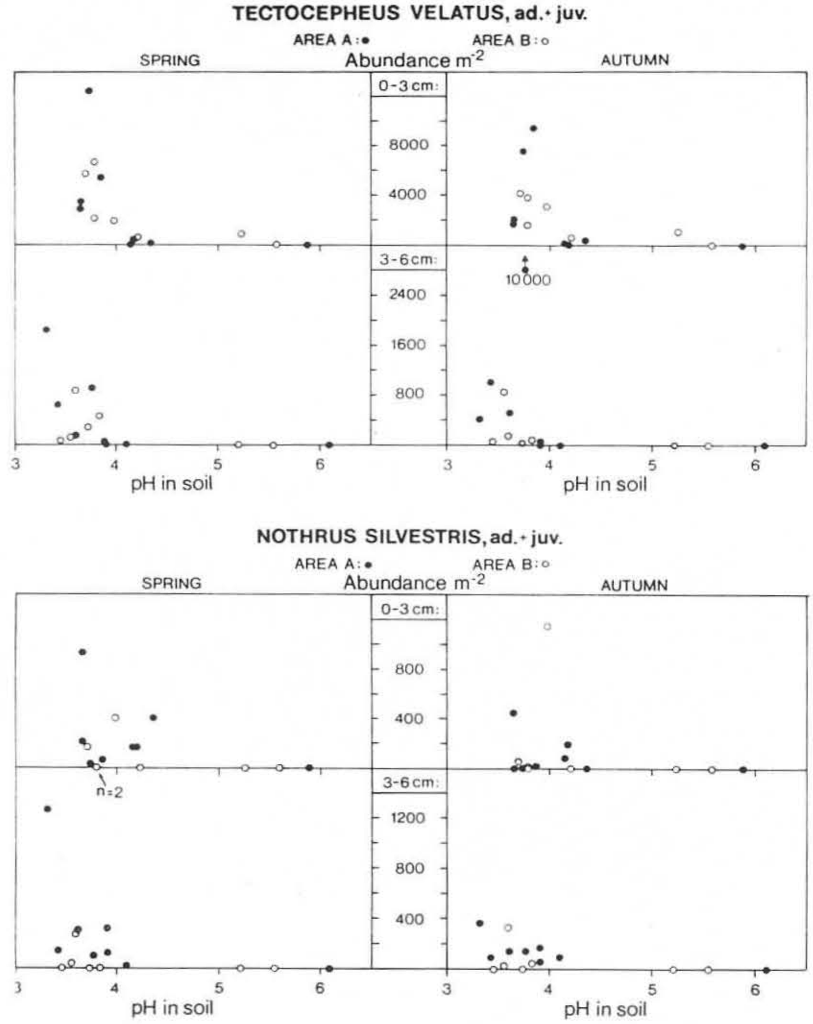

Fig. 2. Abundance of *Tectocepheus velatus* and *Nothrus silvestris* related to soil pH.

4. Discussion

4.1. Relations to vegetation types and soils

Fig. 1 shows that it is meaningful to relate the main distribution of the species to the various plant communities, when these are arranged according to soil fertility. The highest abundance values of each species occur within a characteristic section of the gradient, and the pattern is rather similar in the two study areas. As shown by HÅGVAR (1982), the main distribution of most Collembola species could also be related to the soil fertility scale.

Comparable data for the mite fauna exist mainly from Finland. According to KARPPINEN (1955 and 1958), both *N. silvestris* and *T. velatus* occur in many different plant communities of coniferous forest, but the highest abundance values of these species were observed in medium rich sites (*Eu-Pc My* and *Va-Pn*). In northern Sweden, FORSSLUND (1944) found higher abundance of *T. velatus* in *Eu-Pc My* than in richer habitats. Although the extraction method of these authors (Berlese funnel) was not strictly quantitative, their material probably reflects main trends, and these conform rather well with the present data. Both

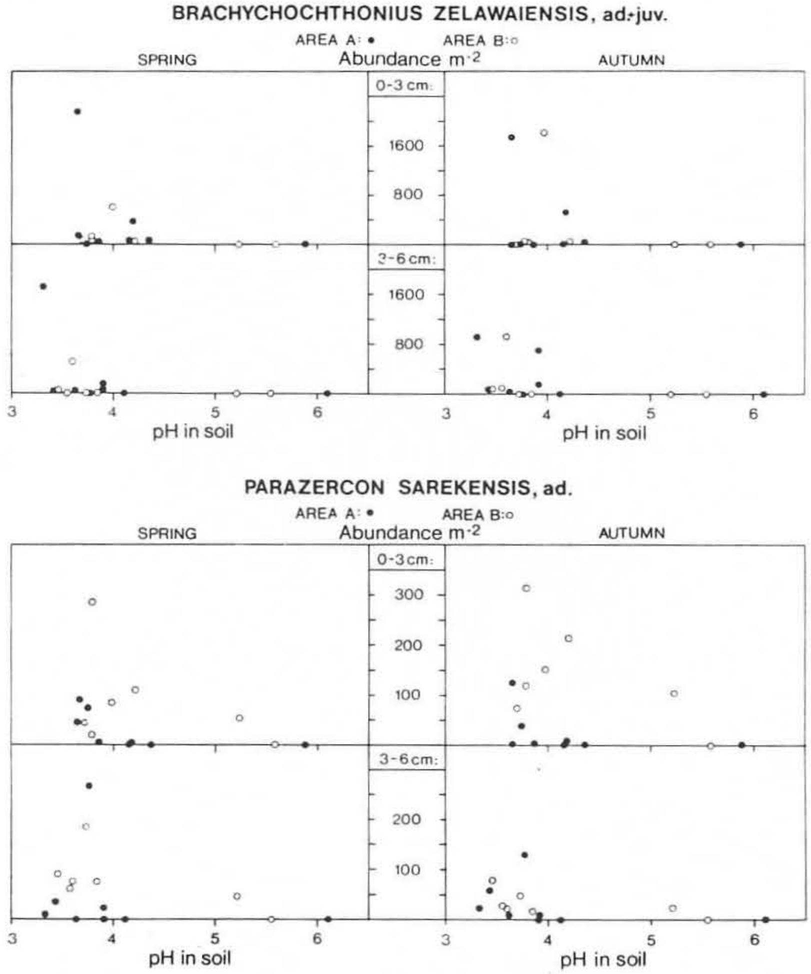

Fig. 3. Abundance of *Brachychochthonius zelawaiensis* and *Parazercon sarekensis* related to soil pH.

authors recorded low numbers of *B. zelawaiensis*, but I would consider the extraction method unsuitable for this small species.

Regarding *T. velatus*, *N. silvestris* and *B. zelawaiensis*, literature data confirm their affinity for raw humus soils (Forsslund 1944, Strenzke 1952, Karppinen 1955 and 1958, Moritz 1976).

4.2. Relations to soil chemical properties

The most reliable relationships between abundance and soil chemical parameters are those which appear in both study areas. In this respect, the correlations found in *T. velatus* seem to be very consistent (Table 1). Among the other species, only the negative relationship to Mg in *P. sarekensis* was noted in both study areas.

Literature data confirm that the highest abundance values of *T. velatus*, *N. silvestris* and *B. zelawaiensis* are found in low pH soils (*cf.* Figs. 2—3) (e.g. Strenzke 1952, Karppinen 1955 and 1958, Moritz 1963 and 1976, Persson 1975). Such soils usually have a well developed raw humus which is low in Ca, Mg and Mn and have a low base saturation (Hågvar & Abrahamsen 1984). It is a common feature of these three species that their abundance, at least in certain samplings, was negatively related to pH, base saturation and Ca (Table 1).

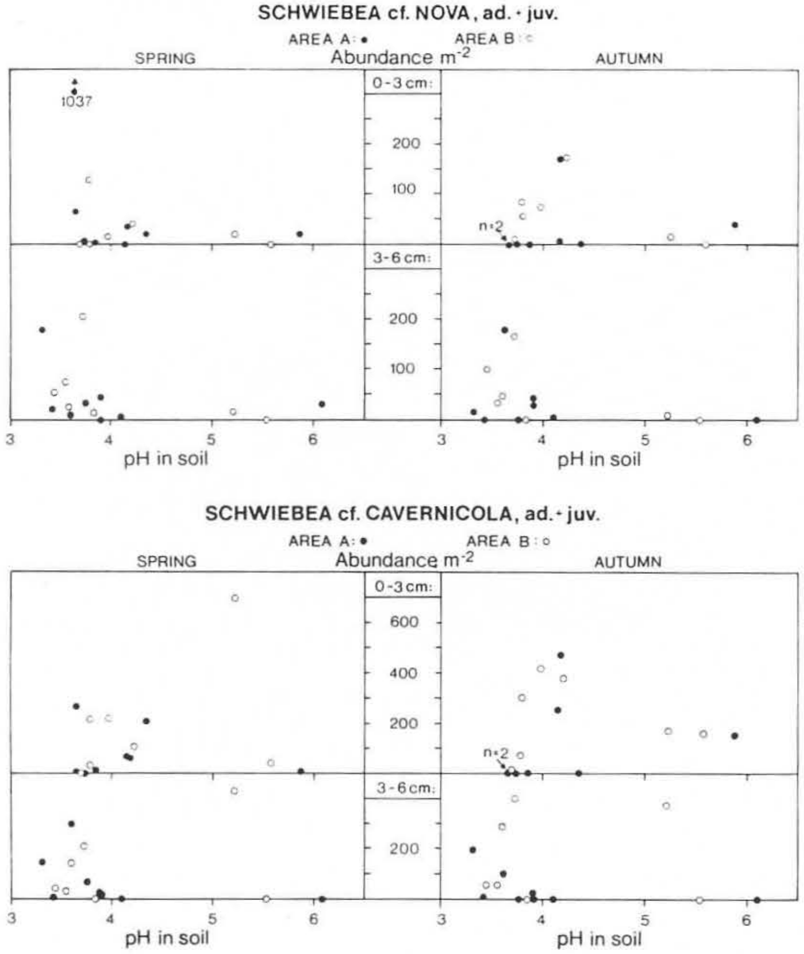

Fig. 4. Abundance of *Schwiebea cf. nova* and *Schwiebea cf. cavernicola* related to soil *p*H.

The less acidophilic character of *S. cf. cavernicola* compared to *S. cf. nova*, observed by HÅGVAR & AMUNDSEN (1981), is reflected in Fig. 4, as the first species may show high densities also in soils with *p*H values above 5. The difference also appears in Table 1, where *S. cf. cavernicola* showed a certain positive relationship to base saturation and Mg. The reduction observed in *P. sarekensis* in artificially acid soil (HÅGVAR & AMUNDSEN 1981) was not clearly reflected in the distribution on different natural soils (Fig. 3). However, the field distribution of this species (*cf.* Table 1) conforms with a negative response to liming, as observed by HÅGVAR & AMUNDSEN (1981).

High abundance of *T. velatus* may have an indicator value for acid soils with low content of base cations. According to Spearman's test, the indicator value of the other five species is limited (Table 1).

In *T. velatus*, *N. silvestris*, *B. zelawaiensis* and *S. cf. nova*, both high and low populations were observed in very acidic soils (*p*H around four or lower), while the abundance was always low in soils with higher *p*H values. It seems that in rich soils, the high *p*H (or correlated factors) acts as a limiting factor, while in a more acid interval, high populations can build up if not other factors become limiting. One limiting factor in a soil of "favourable" *p*H may be the water content (either too dry or too moist).

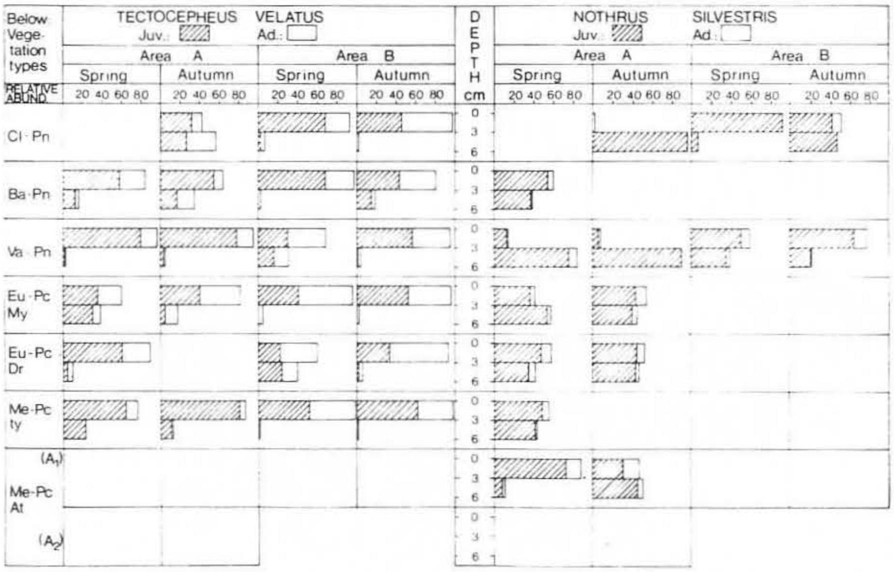

Fig. 5. Depth distribution of *Tectocepheus velatus* and *Nothrus silvestris* in different forest types.

Fig. 6. Depth distribution of *Brachychochthonius zelawaiensis* and *Parazercon sarekensis* in different forest types.

Since microarthropods inhabit the air-filled cavities of the soil and have a hydrophobic body surface, relationships between these animals and soil chemical parameters are probably of an indirect nature. For instance, the microflora on which they feed may be related to soil chemistry, or chemical parameters may be correlated with structural soil characteristics such as pore space and microhabitat diversity. In an analysis like this, one should also be aware that artificial relationships may appear. The present results should therefore be checked in other soils.

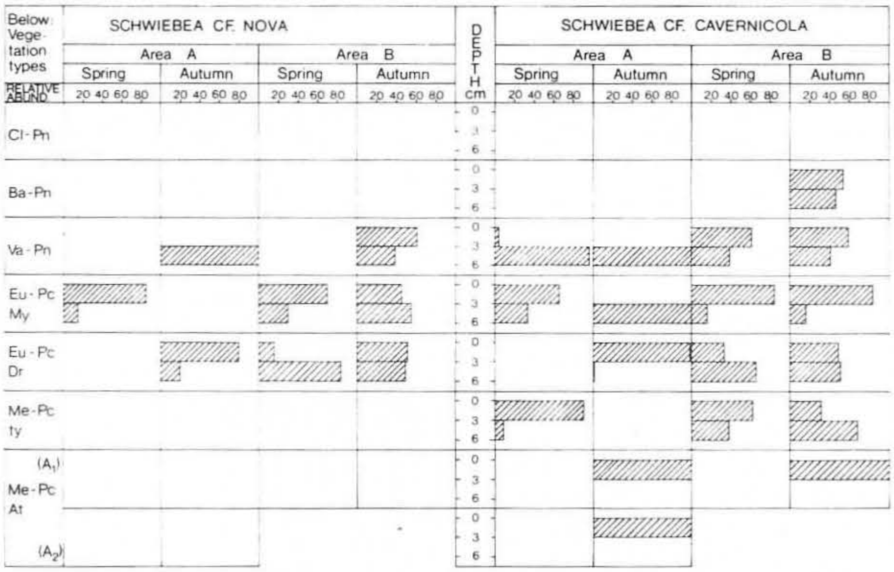

Fig. 7. Depth distribution of *Schwiebea cf. nova* and *Schwiebea cf. cavernicola* in different forest types.

4.3. Vertical distribution

The somewhat deeper distribution of *N. silvestris* compared to *T. velatus* is confirmed by DRIFT (1951), KARPPINEN (1958) and LEBRUN (1971). Large seasonal and local variations in the depth distribution of these species have been observed also in earlier studies, and the deepest distributions have usually been found during winter or dry summer periods (STRENZKE 1952, KARPPINEN 1955 and 1958, LEBRUN 1971, PANDE & BERTHET 1975).

Clearly, all the six species in the present study have the ability continually to adjust their vertical distribution according to varying environmental conditions. This flexibility was apparent also for the Collembola species in the same soils (HÅGVAR 1983).

5. Acknowledgements

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6. Résumé

(Six espèces communes d' acariens (Acarina) dans les sols des forêts de conifères en Norvège: rapports avec les types de végétation et les caractéristiques des sols).

Dans deux zones d'étude, l'abondance de six espèces banales d'acariens a été étudiée dans sept types différents de forêts de conifères. Des échantillons ont été prélevés dans les couches de 0—3 cm et de 3—6 cm au printemps et en automne. Trois espèces appartenaient aux Oribatei *(Tectocepheus velatus, Nothrus silvestris* et *Brachychochthonius zelawaiensis)*, deux aux Astigmata (*Schwiebea cf. nova* et *S. cf. cavernicola)*, et une aux Mesostigmata *(Parazercon sarekensis)*.

Les trois espèces d'Oribatei et *S. cf. nova* apparaissaient principalement dans les podzols pauvres et acides à humus brut, ce qui concorde avec des expériences précédentes sur l'acidification et le chaulage, dans lesquelles ces quatres espèces avaient montré des caractéristiques «acidophiles». Les deux autres espèces ont été aussi trouvées abondamment dans un sol brun pauvre, tandis qu'aucune des six espèces n'abondait dans les sites de sol brun riche à mull. Les rapports avec les paramètres chimiques des sols ont été quantifiés na moyen du test de Spearman (analyse par corrélation).

Toutes les espèces ont montré de fortes variations en ce qui concerne leur distribution verticale en fonction des habitats et des saisons. En moyenne, le pourcentage suivant des populations a été observé dans les 3 cm supérieurs: 85% pour *T. velatus*, 65% pour *P. sarekensis*, 60% pour *S. cf. cavernicola*, 54% pour *B. zelawaiensis*, 52% pour *N. silvestris* et 51% pour *S. cf. nova*.

Mots clef: Acarina, forêt de conifère, communautés de plantes, types de sol, fertilité du sol, chimie du sol, distribution verticale.

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HÅGVAR, S., 1984. Six common mite species (Acari) in Norwegian coniferous forest soils: Relations to vegetation types and soil characteristics. Pedobiologia **27**, 355—364.

In each of two study areas, the abundances of six common mite species were studied in seven different vegetation types of coniferous forest. Samples were taken in the 0—3 cm and 3—6 cm layers in spring and autumn. Three species belonged to Oribatei (*Tectocepheus velatus*, *Nothrus silvestris* and *Brachychochthonius zelawaiensis*), two belonged to Astigmata (*Schwiebea cf. nova* and *S. cf. cavernicola*), and one to Mesostigmata (*Parazercon sarekensis*).

The three Oribatei species and *S. cf. nova* occurred mainly in poor and acidic podzol soils with raw humus. This finding conforms with the results from earlier acidification and liming experiments, in which these four species showed an "acidophilic" character. The two other species were also found abundantly in a poor brown earth soil, while none of the six species were abundant in rich brown earth sites with mull humus. Correlations to soil chemical parameters was carried out by using Spearman's rank correlation coefficient.

All species showed large variations in depth distribution, both between habitats and seasons. On the average, the following percentages of the populations occurred in the upper 3 cm: 85% in *T. velatus*, 65% in *P. sarekensis*, 60% in *S. cf. cavernicola*, 54% in *B. zelawaiensis*, 52% in *N. silvestris* and 51% in *S. cf. nova*.

Key words: Acari, coniferous forest, plant communities, soil types, soil fertility, soil chemistry vertical distribution.